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[MTD 3: Mechanical Testing of Metals]

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Indian Standard

METHOD FOR KNOOP HARDNESS TESTING OF METALS

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METHOD FOR KNOOP HARDNESS TESTING OF METALS

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Indian Standard

METHOD FOR KNOOP HARDNESS TESTING OF METALS

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 28 February 1973, after the draft finalized by the Methods of Physical Tests Sectional Committee had been approved by the Structural and Metals Division Council.

0.2 This standard has been prepared in order to establish a uniform procedure for knoop hardness testing of metals.

0.3 Knoop hardness testing refers to hardness testing with micro-indentation obtained at small loads.

0.3.1 Microhardness testing is used increasingly in the identification of different types of structural constituents of metals and alloys where the maximum dimensions of constituents is only a few microns, and for quality assessment of very small work-pieces or very thin pieces.

0.3.2 Knoop hardness testing has the following advantages:

a) Measurement of hardness of very thin coatings or layers, particularly sections at right angles (depth of indentation being 1/30 of the length of the diagonal).

b) Also useful for evaluating hard and brittle substances, such as glass, carbides and oxides and studying crystal orientation effects on hardness.

0.4 In the preparation of this standard, assistance has been taken from ASTM E 384-1969 ' Standard method of test for microhardness of materials ' issued by the American Society for Testing and Materials.

0.5 In reporting the result of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS : 2-1960*.

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1. SCOPE

1.1 This standard prescribes the methods for knoop hardness testing of metals under test loads in the range of 1 gf to 1 000 gf.

*Rules for rounding off numerical values (*revised*).

2. PRINCIPLE OF TEST

2.1 The test consists in forcing a diamond indenter in the form of a rhomboid-based pyramid and specified angles between opposite faces at the vertex (*see* Fig. 1), into the metal under a load F and measuring the diagonal d of the indentation left in the surface of the test piece after removal of the load.

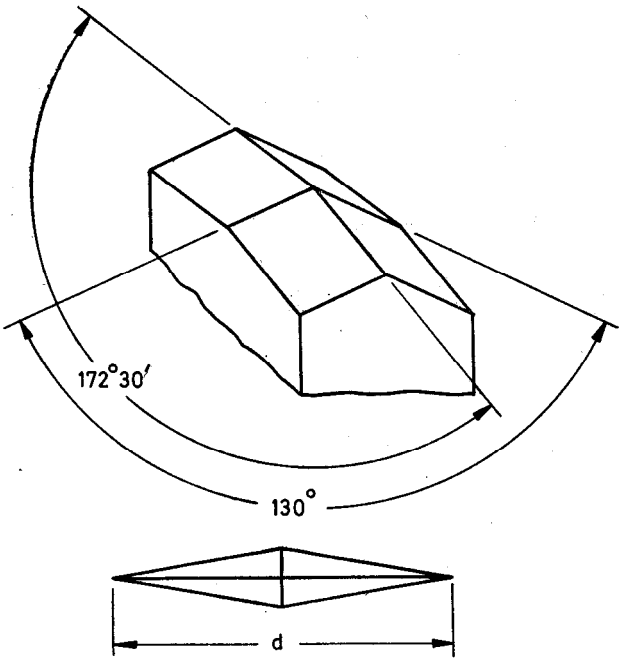

FIG. 1 KNOOP INDENTER

2.2 The knoop hardness value is the quotient obtained by dividing the test load F (expressed in kilograms-force) by the sloping area of the indentation (in mm^2).

3. REFERENCE SYMBOLS

3.1 The following reference symbols have been used in this standard:

Reference Symbols	*Description*
F	Applied load
d	Length of longer diagonal of the indentation
HK	Knoop hardness

3.2

$$HK = \frac{\text{Applied load in kgf}}{\text{Area of indentation in mm}^2}$$

$$= \frac{F}{\frac{1}{2}\cot\frac{1}{2}(172°30')\tan\frac{1}{2}(130°)\ d^2}$$

$$= \frac{F}{0{\cdot}070\ 28\ d^2}$$

3.2.1 Since the units normally used are gram-force and micrometres rather than kilogram-force and millimetres, the equation for knoop hardness number can be expressed conveniently as:

$$HK = 14\ 229\ \frac{F}{d^2}$$

where

F = load in gf, and

d = length of longer diagonal in micrometres (μm).

3.2.2 The knoop hardness numbers are given in Table 1 for a test load of 1 gf. For obtaining hardness numbers when other test loads are used, the knoop hardness number, obtained from Table 1, is multiplied by the test load in gram-force.

4. TESTING EQUIPMENT

4.1 Testing Machine — Equipment for knoop hardness testing usually consists of a testing machine that supports the specimen and permits the indenter and specimen to be brought into contact gradually and smoothly under a predetermined load. The design of the machine should be such that no rocking or lateral movement of the indenter or specimen is permitted while the load is being applied or removed. A measuring microscope is usually mounted on the machine in such a manner that the indentation may be readily located in the field of view.

4.1.1 The microhardness testing machine shall be located in an area as free from vibrations as possible in order to avoid erroneous results. It is necessary to mount the machine on thick rubber paddings or a plastic foam base for damping external vibrations. Where vibrations are encountered, a vibration meter should be used to check if the vibrations are adequately damped.

4.2 The testing machine should be regularly checked in accordance with 'Method for verification of knoop hardness testing machines' (*under preparation*).

TABLE 1 KNOOP HARDNESS NUMBERS FOR LOAD OF 1 gf

(*Clause* 3.2.2)

Diagonal of Impression µm	Knoop Hardness Number									
	0·0	0·1	0·2	0·3	0·4	0·5	0·6	0·7	0·8	0·9
1	14230	11760	9881	8420	7260	6324	5558	4924	4392	3942
2	3557	3227	2940	2690	2470	2277	2105	1952	1815	1692
3	1581	1481	1390	1307	1231	1162	1098	1039	985·4	935·5
4	889·3	846·5	806·6	769·5	735·0	702·7	672·4	644·1	617·6	592·6
5	569·2	547·1	526·2	506·2	488·0	470·4	453·7	437·9	423·0	408·8
6	395·2	382·4	370·2	358·5	347·4	336·7	326·7	317·0	307·7	298·9
7	290·4	282·3	274·5	267·0	259·8	253·0	246·3	240·0	233·9	228·0
8	222·3	216·9	211·6	206·5	201·7	196·9	192·4	188·0	183·7	179·6
9	175·7	171·8	168·1	164·5	161·0	157·7	154·4	151·2	148·2	145·2
10	142·3	139·5	136·8	134·1	131·6	129·1	126·6	124·3	122·0	119·8
11	117·6	115·5	113·4	111·4	109·5	107·6	105·7	103·9	102·2	100·5
12	98·81	97·19	95·60	94·05	92·54	91·07	89·63	88·22	86·85	85·51
13	84·20	82·91	81·66	80·44	79·24	78·07	76·93	75·81	74·72	73·65
14	72·60	71·57	70·57	69·58	68·62	67·68	66·75	65·85	64·96	64·09
15	63·24	62·40	61·59	60·78	60·00	59·23	58·47	57·73	57·00	56·28
16	55·58	54·89	54·22	53·55	52·90	52·26	51·64	51·02	50·41	49·82
17	49·24	48·66	48·10	47·54	47·00	46·46	45·94	45·42	44·91	44·41
18	43·92	43·43	42·96	42·49	42·03	41·57	41·13	40·69	40·26	39·83
19	39·42	39·00	38·60	38·20	37·81	37·42	37·04	36·66	36·29	35·93
20	35·57	35·22	34·87	34·53	34·19	33·86	33·53	33·21	32·89	32·57
21	32·27	31·96	31·66	31·86	31·07	30·78	30·50	30·22	29·94	29·67
22	29·48	29·13	28·87	28·61	28·36	28·11	27·86	27·61	27·37	27·13
23	26·90	26·67	26·44	26·21	25·99	25·77	25·55	25·33	25·12	24·91
24	24·70	24·50	24·30	24·10	23·90	23·71	23·51	23·32	23·14	22·95
25	22·77	22·59	22·41	22·23	22·05	21·88	21·71	21·54	21·38	21·21

26	21·05	20·89	20·73	20·57	20·42	20·26	20·11	19·96	19·81	19·66
27	19·52	19·37	19·23	19·09	18·95	18·82	18·68	18·546	18·41	18·28
28	18·15	18·02	17·89	17·77	17·64	17·52	17·40	17·27	17·15	17·04
29	16·92	16·80	16·69	16·57	16·46	16·35	16·24	16·13	16·02	15·92
30	15·81	15·71	15·60	15·50	15·40	15·30	15·20	15·10	15·00	14·90
31	14·81	14·71	14·62	14·52	14·43	14·34	14·25	14·16	14·07	13·98
32	13·90	13·81	13·72	13·64	13·55	13·47	13·39	13·31	13·23	13·15
33	13·07	12·99	12·91	12·83	12·75	12·68	12·60	12·53	12·45	12·38
34	12·31	12·24	12·17	12·09	12·02	11·95	11·89	11·82	11·75	11·68
35	11·62	11·55	11·48	11·42	11·35	11·29	11·23	11·16	11·10	11·04
36	10·98	10·92	10·86	10·80	10·74	10·68	10·62	10·56	10·51	10·45
37	10·39	10·34	10·28	10·23	10·17	10·12	10·06	10·01	9·958	9·906
38	9·854	9·802	9·751	9·700	9·650	9·600	9·550	9·501	9·452	9·403
39	9·355	9·307	9·260	9·213	9·166	9·120	9·074	9·028	8·983	8·938
40	8·893	8·849	8·805	8·761	8·718	8·675	8·632	8·500	8·548	8·506
41	8·465	8·423	8·383	8·342	8·302	8·262	8·222	8·183	8·144	8·105
42	8·066	8·028	7·990	7·952	7·915	7·878	7·841	7·804	7·768	7·731
43	7·695	7·660	7·624	7·589	7·554	7·520	7·485	7·451	7·417	7·383
44	7·350	7·316	7·283	7·250	7·218	7·185	7·153	7·121	7·090	7·058
45	7·027	6·996	6·965	6·934	6·903	6·873	6·843	6·813	6·783	6·754
46	6·724	6·695	6·666	6·638	6·609	6·581	6·552	6·524	6·497	6·469
47	6·441	6·414	6·387	6·360	6·333	6·306	6·280	6·254	6·228	6·202
48	6·176	6·150	6·125	6·090	6·074	6·049	6·024	6·000	5·975	5·951
49	5·926	5·902	5·878	5·854	5·831	5·807	5·784	5·761	5·737	5·714
50	5·692	5·669	5·646	5·624	5·002	5·579	5·557	5·536	5·514	5·492
51	5·471	5·449	5·428	5·407	5·386	5·365	5·344	5·323	5·303	5·282
52	5·262	5·242	5·222	5·202	5·182	5·162	5·143	5·123	5·104	5·085
53	5·065	5·046	5·027	5·009	4·990	4·971	4·953	4·934	4·916	4·898
54	4·880	4·862	4·844	4·826	4·808	4·790	4·773	4·756	4·738*	4·721
55	4·704	4·687	4·670	4·653	4·636	4·619	4·603	4·586	4·570	4·554

(*Continued*)

TABLE 1 KNOOP HARDNESS NUMBERS FOR LOAD OF 1 gf — *Contd*

Diagonal of Impression μm	Knoop Hardness Number									
	0·0	0·1	0·2	0·3	0·4	0·5	0·6	0·7	0·8	0·9
56	4·537	4·521	4·505	4·489	4·473	4·457	4·442	4·426	4·410	4·395
57	4·379	4·364	4·349	4·334	4·319	4·304	4·289	4·274	4·259	4·244
58	4·230	4·215	4·201	4·186	4·172	4·158	4·144	4·129	4·115	4·102
59	4·088	4·074	4·060	4·046	4·033	4·019	4·006	3·992	3·979	3·966
60	3·952	3·939	3·926	3·913	3·900	3·887	3·875	3·862	3·849	3·837
61	3·824	3·811	3·799	3·787	3·774	3·762	3·750	3·738	3·726	3·714
62	3·702	3·690	3·678	3·666	3·654	3·643	3·631	3·619	3·608	3·596
63	3·585	3·574	3·562	3·551	3·540	3·529	3·518	3·507	3·496	3·485
64	3·474	3·463	3·452	3·442	3·431	3·420	3·410	3·399	3·389	3·378
65	3·368	3·357	3·347	3·337	3·327	3·317	3·306	3·296	3·286	3·276
66	3·267	3·257	3·247	3·237	3·227	3·218	3·208	3·198	3·189	3·179
67	3·170	3·160	3·151	3·142	3·132	3·123	3·114	3·105	3·095	3·086
68	3·077	3·068	3·059	3·050	3·041	3·032	3·024	3·015	3·006	2·997
69	2·989	2·980	2·971	2·963	2·954	2·946	2·937	2·929	2·921	2·912
70	2·904	2·896	2·887	2·879	2·871	2·863	2·855	2·847	2·839	2·831
71	2·823	2·815	2·807	2·799	2·791	2·783	2·776	2·768	2·760	2·752
72	2·745	2·737	2·730	2·722	2·715	2·707	2·700	2·692	2·685	2·677
73	2·670	2·663	2·656	2·648	2·641	2·634	2·627	2·620	2·613	2·605
74	2·598	2·591	2·584	2·577	2·571	2·564	2·557	2·550	2·543	2·536
75	2·530	2·523	2·516	2·509	2·503	2·496	2·490	2·483	2·476	2·470
76	2·463	2·457	2·451	2·444	2·438	2·431	2·425	2·419	2·412	2·406
77	2·400	2·394	2·387	2·381	2·375	2·369	2·363	2·357	2·351	2·345
78	2·339	2·333	2·327	2·321	2·315	2·309	2·303	2·297	2·292	2·286
79	2·280	2·274	2·268	2·263	2·257	2·251	2·246	2·240	2·234	2·229
80	2·223	2·218	2·212	2·207	2·201	2·196	2·190	2·185	2·179	2·174

81	2·169	2·163	2·158	2·153	2·147	2·142	2·137	2·132	2·127	2·121
82	2·116	2·111	2·106	2·101	2·096	2·091	2·086	2·080	2·075	2·070
83	2·065	2·060	2·056	2·051	2·046	2·041	2·036	2·031	2·026	2·021
84	2·017	2·012	2·007	2·002	1·998	1·993	1·988	1·983	1·979	1·974
85	1·969	1·965	1·960	1·956	1·951	1·946	1·942	1·937	1·933	1·928
86	1·924	1·919	1·915	1·911	1·906	1·902	1·897	1·893	1·889	1·884
87	1·880	1·876	1·871	1·867	1·863	1·858	1·854	1·850	1·846	1·842
88	1·837	1·833	1·829	1·825	1·821	1·817	1·813	1·809	1·804	1·800
89	1·796	1·792	1·788	1·784	1·780	1·776	1·772	1·768	1·765	1·761
90	1·757	1·753	1·749	1·745	1·741	1.737	1·733	1·730	1·726	1·722
91	1·718	1·715	1·711	1·707	1·703	1·700	1·696	1·692	1·688	1·685
92	1·681	1·677	1·674	1·670	1·667	1·663	1·659	1·656	1·652	1·649
93	1·645	1·642	1·638	1·635	1·631	1·628	1·624	1·621	1·617	1·614
94	1·610	1·607	1·604	1·600	1·597	1·593	1·590	1·587	1·583	1·580
95	1·577	1·573	1·570	1·567	1·563	1·560	1·557	1·554	1·550	1·547
96	1·544	1·541	1·538	1·534	1·531	1·528	1·525	1·522	1·519	1·510
97	1·512	1·509	1·506	1.503	1·500	1·497	1·494	1·491	1·488	1·485
98	1·482	1·479	1·476	1·473	1·470	1·467	1·464	1·461	1·458	1·455
99	1·452	1·449	1·446	1·443	1·440	1·437	1·434	1·431	1·429	1·426
100	1·423	1·420	1·417	1·414	1·412	1·409	1·406	1·403	1·400	1·398
101	1·395	1·392	1·389	1·387	1·384	1·381	1·378	1·376	1·373	1·370
102	1·368	1·365	1·362	1·360	1·357	1·354	1·352	1·349	1·346	1·344
103	1·341	1·339	1·336	1·333	1·331	1·328	1·326	1·323	1·321	1·318
104	1·316	1·313	1·311	1·308	1·305	1·303	1·301	1·298	1·296	1·293
105	1·291	1·288	1·286	1·283	1·281	1·278	1·276	1·274	1·271	1·269
106	1·266	1·264	1·262	1·259	1·257	1·255	1·252	1·250	1·247	1·245
107	1·243	1·240	1·238	1·236	1·234	1·231	1·229	1·227	1·224	1·222
108	1·220	1·218	1·215	1·213	1·211	1·209	1·206	1·204	1·202	1·200
109	1·198	1·195	1·193	1·191	1·189	1·187	1·185	1·182	1·180	1·178
110	1·176	1·174	1·172	1·170	1·167	1·165	1·163	1·161	1·159	1·157

(*Continued*)

TABLE 1 KNOOP HARDNESS NUMBERS FOR LOAD OF 1 gf — *Contd*

Diagonal of Impression µm	Knoop Hardness Number									
	0·0	0·1	0·2	0·3	0·4	0·5	0·6	0·7	0·8	0·9
111	1·155	1·153	1·151	1·149	1·147	1·145	1·142	1·140	1·138	1·136
112	1·134	1·132	1·130	1·128	1·126	1·124	1·122	1·120	1·118	1·116
113	1·114	1·112	1·110	1·108	1·106	1·105	1·103	1·101	1·099	1·097
114	1·095	1·093	1·091	1·089	1·087	1·085	1·083	1·082	1·080	1·078
115	1·076	1·074	1·072	1·070	1·068	1·067	1·065	1·063	1·061	1·059
116	1·057	1·056	1·054	1·052	1·050	1·048	1·047	1·045	1·043	1·041
117	1·039	1·038	1·036	1·034	1·032	1·031	1·029	1·027	1·025	1·024
118	1·022	1·020	1·018	1·017	1·015	1·013	1·012	1·010	1·008	1·006
119	1·005	1·003	1·001	0·999 8	0·998 1	0·996 4	0·994 7	0·993 1	0·991 4	0·989 8
120	0·988 1	0·986 5	0·984 8	0·983 2	0·981 6	0·979 9	0·978 3	0·976 7	0·975 1	0·973 5
121	0·971 9	0·970 3	0·968 7	0·967 1	0·965 5	0·963 9	0·962 3	0·960 7	0·959 1	0·957 6
122	0·956 0	0·954 4	0·952 9	0·951 3	0·949 8	0·948 2	0·946 7	0·945 1	0·943 6	0·942 0
123	0·940 5	0·939 0	0·937 5	0·935 9	0·934 4	0·932 9	0·931 4	0·929 9	0·928 4	0·926 9
124	0·925 4	0·923 9	0·922 4	0·920 9	0·919 5	0·918 0	0·916 5	0·915 0	0·913 6	0·912 1
125	0·910 7	0·909 2	0·907 8	0·906 3	0·904 9	0·903 4	0·902 0	0·900 5	0·899 1	0·897 7
126	0·896 3	0·894 8	0·893 4	0·892 0	0·890 6	0·889 2	0·887 8	0·886 4	0·885 0	0·883 6
127	0·882 2	0·880 8	0·879 4	0·878 0	0·876 7	0·875 3	0·873 9	0·872 6	0·871 2	0·869 8
128	0·868 5	0·867 1	0·865 8	0·864 4	0·863 1	0·861 7	0·860 4	0·859 1	0·857 7	0·856 4
129	0·855 1	0·853 7	0·852 4	0·851 1	0·849 8	0·848 5	0·847 2	0·845 9	0·844 6	0·843 3
130	0·842 0	0·840 7	0·839 4	0·838 1	0·836 8	0·835 8	0·834 3	0·833 0	0·831 7	0·830 4
131	0·829 1	0·827 9	0·826 6	0·825 4	0·824 1	0·822 9	0·821 6	0·820 4	0·819 1	0·817 9
132	0·816 6	0·815 4	0·814 2	0·812 9	0·811 7	0·810 5	0·809 3	0·808 0	0·806 8	0·805 6
133	0·804 4	0·803 2	0·802 0	0·800 8	0·799 6	0·798 4	0·797 2	0·796 0	0·794 8	0·793 6
134	0·792 4	0·791 3	0·790 1	0·788 9	0·787 7	0·786 6	0·785 4	0·784 2	0·783 1	0·781 9
135	0·780 7	0·779 6	0·778 4	0·777 3	0·776 1	0·775 0	0·773 8	0·772 7	0·771 6	0·770 4

136	0·769 3	0·768 2	0·767 0	0·765 9	0·764 8	0·763 7	0·762 6	0·761 4	0·760 3	0·759 2
137	0·758 1	0·757 0	0·755 9	0·754 8	0·753 7	0·752 6	0·751 5	0·750 4	0·749 3	0·748 3
138	0·747 2	0·746 1	0·745 0	0·743 9	0·742 9	0·741 8	0·740 7	0·739 6	0·738 6	0·737 5
139	0·736 5	0·735 4	0·734 3	0·733 3	0·732 2	0·731 2	0·730 1	0·729 1	0·728 1	0·727 0
140	0·726 0	0·724 9	0·723 9	0·722 9	0·721 8	0·720 8	0·719 8	0·718 8	0·717 7	0·716 7
141	0·715 7	0·714 7	0·713 7	0·712 7	0·711 7	0·710 7	0·709 7	0·708 7	0·707 7	0·706 7
142	0·705 7	0·704 7	0·703 7	0·702 7	0·701 7	0·700 7	0·699 7	0·698 8	0·697 8	0·696 8
143	0·695 8	0·694 9	0·693 9	0·692 9	0·692 0	0·691 0	0·690 0	0·689 1	0·688 1	0·687 2
144	0·686 2	0·685 2	0·684 3	0·683 4	0·682 4	0·681 5	0·680 5	0·679 6	0·678 6	0·677 7
145	0·676 8	0·675 8	0·674 9	0·674 0	0·673 1	0·672 1	0·671 2	0·670 3	0·669 4	0·668 4
146	0·667 5	0·666 6	0·665 7	0·664 8	0·663 9	0·663 0	0·662 1	0·661 2	0·660 3	0·659 4
147	0·658 5	0·657 6	0·656 7	0·655 8	0·654 9	0·654 0	0·653 1	0·652 3	0·651 4	0·650 5
148	0·649 6	0·648 7	0·647 9	0·647 0	0·646 1	0·645 2	0·644 4	0·643 5	0·642 6	0·641 8
149	0·640 9	0·640 1	0·639 2	0·638 3	0·637 5	0·636 6	0·635 8	0·634 9	0·634 1	0·633 2
150	0·632 4	0·631 6	0·630 7	0·629 9	0·629 0	0·628 2	0·627 4	0·626 5	0·625 7	0·624 9
151	0·624 1	0·623 2	0·622 4	0·621 6	0·620 8	0·619 9	0·619 1	0·618 3	0·617 5	0·616 7
152	0·615 9	0·615 1	0·614 3	0·613 4	0·612 6	0·611 8	0·611 0	0·610 2	0·609 4	0·608 6
153	0·607 8	0·607 1	0·606 3	0·605 5	0·604 7	0·603 9	0·603 1	0·602 3	0·601 5	0·600 8
154	0·600 0	0·599 2	0·598 4	0·597 6	0·596 9	0·596 1	0·595 3	0·594 6	0·593 8	0·593 0
155	0·592 3	0·591 5	0·590 7	0·590 0	0·589 2	0·588 5	0·587 7	0·586 9	0·586 2	0·585 4
156	0·584 7	0·583 9	0·583 2	0·582 5	0·581 7	0·581 0	0·580 2	0·579 5	0·578 7	0·578 0
157	0·577 3	0·576 5	0·575 8	0·575 1	0·574 3	0·573 6	0·572 9	0·572 2	0·571 4	0·570 7
158	0·570 0	0·569 3	0·568 5	0·567 8	0·567 1	0·566 4	0·565 7	0·565 0	0·564 3	0·563 5
159	0·562 8	0·562 1	0·561 4	0·560 7	0·560 0	0·559 3	0·558 6	0·557 9	0·557 2	0·556 5
160	0·555 8	0·555 1	0·554 4	0·553 7	0·553 1	0·552 4	0·551 7	0·551 0	0·550 3	0·549 6
161	0·548 9	0·548 3	0·547 6	0·546 9	0·546 2	0·545 5	0·544 9	0·544 2	0·543 5	0·542 9
162	0·542 2	0·541 5	0·540 8	0·540 2	0·539 5	0·538 9	0·538 2	0·537 5	0·536 9	0·536 2
163	0·535 6	0·534 9	0·534 2	0·533 6	0·532 9	0·532 3	0·531 6	0·531 0	0·530 3	0·529 7
164	0·529 0	0·528 4	0·527 8	0·527 1	0·526 5	0·525 8	0·525 2	0·524 6	0·523 9	0·523 3
165	0·522 6	0·522 0	0·521 4	0·520 8	0·520 1	0·519 5	0·518 9	0·518 2	0·517 6	0·517 0

(*Continued*)

TABLE 1 KNOOP HARDNESS NUMBERS FOR LOAD OF 1 gf — *Contd*

Diagonal of Impression µm	Knoop Hardness Number									
	0·0	0·1	0·2	0·3	0·4	0·5	0·6	0·7	0·8	0·9
166	0·516 4	0·515 7	0·515 1	0·514 5	0·513 9	0·513 3	0·512 7	0·512 0	0·511 4	0·510 8
167	0·510 2	0·509 6	0·509 0	0·508 4	0·507 8	0·507 2	0·506 6	0·506 0	0·505 4	0·504 7
168	0·504 1	0·503 5	0·503 0	0·502 4	0·501 8	0·501 2	0·500 6	0·500 0	0·499 4	0·498 8
169	0·493 2	0·497 6	0·497 0	0·496 4	0·495 9	0·495 3	0·494 7	0·494 1	0·493 5	0·492 9
170	0·492 4	0·491 8	0·491 2	0·490 6	0·490 0	0·489 5	0·488 9	0·488 3	0·487 8	0·487 2
171	0·486 6	0·486 0	0·485 5	0·484 9	0·484 3	0·483 8	0·483 2	0·482 7	0·482 1	0·481 5
172	0·481 0	0·480 4	0·479 9	0·479 3	0·478 7	0·478 2	0·477 6	0·477 1	0·476 5	0·476 0
173	0·475 4	0·474 9	0·474 3	0·473 8	0·473 2	0·472 7	0·472 1	0·471 6	0·471 1	0·470 5
174	0·470 0	0·469 4	0·468 9	0·468 4	0·467 8	0·467 3	0·466 8	0·466 2	0·465 7	0·465 2
175	0·464 6	0·464 1	0·463 6	0·463 0	0·462 5	0·462 0	0·461 5	0·460 9	0·460 4	0·459 9
176	0·459 4	0·458 8	0·458 3	0·457 8	0·457 3	0·456 8	0·456 2	0·455 7	0·455 2	0·454 7
177	0·454 2	0·453 7	0·453 2	0·452 6	0·452 1	0·451 6	0·451 1	0·450 6	0·450 1	0·449 6
178	0·449 1	0·448 6	0·448 1	0·447 6	0·447 1	0·446 6	0·446 1	0·445 6	0·445 1	0·444 6
179	0·444 1	0·443 6	0·443 1	0·442 6	0·442 1	0·441 6	0·441 1	0·440 6	0·440 1	0·439 7
180	0·439 2	0·438 7	0·438 2	0·437 7	0·437 2	0·436 7	0·436 3	0·435 8	0·435 3	0·434 8
181	0·434 3	0·433 9	0·433 4	0·432 9	0·432 4	0·431 9	0·431 5	0·431 0	0·430 5	0·430 0
182	0·429 6	0·429 1	0·428 6	0·428 2	0·427 7	0·427 2	0·426 8	0·426 3	0·425 8	0·425 4
183	0·424 9	0·424 4	0·424 0	0·423 5	0·423 0	0·422 6	0·422 1	0·421 7	0·421 2	0·420 7
184	0·420 3	0·419 8	0·419 4	0·418 9	0·418 5	0·418 0	0·417 6	0·417 1	0·416 7	0·416 2
185	0·415 8	0·415 3	0·414 9	0·414 4	0·414 0	0·413 5	0·413 1	0·412 6	0·412 2	0·411 7
186	0·411 3	0·410 9	0·410 4	0·410 0	0·409 5	0·409 1	0·408 7	0·408 2	0·407 8	0·407 3
187	0·406 9	0·406 5	0·406 0	0·405 6	0·405 2	0·404 7	0·404 3	0·403 9	0·403 4	0·403 0
188	0·402 6	0·402 2	0·401 7	0·401 3	0·400 9	0·400 5	0·400 0	0·399 6	0·399 2	0·398 8
189	0·398 3	0·397 9	0·397 5	0·397 1	0·396 7	0·396 2	0·395 8	0·395 4	0·395 0	0·394 6
190	0·394 2	0·393 7	0·393 3	0·392 9	0·392 5	0·392 1	0·391 7	0·391 3	0·390 9	0·390 5

191	0·390 0	0·389 6	0·389 2	0·388 8	0·388 4	0·388 0	0·387 6	0·387 2	0·386 8	0·386 4
192	0·386 0	0·385 6	0·385 2	0·384 8	0·384 4	0·384 0	0·383 6	0·383 2	0·382 8	0·382 4
193	0·382 0	0·381 6	0·381 2	0·380 8	0·380 4	0·380 0	0·379 6	0·379 2	0·378 9	0·378 5
194	0·378 1	0·377 7	0·377 3	0·376 9	0·376 5	0·376 1	0·375 7	0·375 4	0·375 0	0·374 6
195	0·374 2	0·373 8	0·373 4	0·373 1	0·372 7	0·372 3	0·371 9	0·371 5	0·371 2	0·370 8
196	0·370 4	0·370 0	0·369 6	0·369 3	0·368 9	0·368 5	0·368 1	0·367 8	0·367 4	0·367 0
197	0·366 3	0·366 3	0·365 9	0·365 5	0·365 2	0·364 8	0·364 4	0·364 1	0·363 7	0·363 3
198	0·363 0	0·362 6	0·362 2	0·361 9	0·361 5	0·361 1	0·360 8	0·360 4	0·360 0	0·359 7
199	0·359 3	0·359 0	0·358 6	0·358 2	0·357 9	0·357 5	0·357 2	0·356 8	0·356 4	0·356 1
200	0·355 7	0·355 4	0·355 0	0·354 7	0·354 3	0·354 0	0·353 6	0·353 3	0·352 9	0·352 5

4.3 Indenter — The indenter shall be a diamond tipped straight rhomboid-based pyramid, with an angle at the vertex between two opposite edges of 172° 30′ ± 5′ in the lengthwise direction and 130°0′ in the breadth wise direction. For other geometric characteristics, *see* Fig. 1.

4.3.1 The four faces of the indenter shall be equally inclined to the axis of the indenter (within ± 30′) and shall meet at a sharp point. The line of junction between opposite faces (offset) shall be not more than 1 μm in length (*see* Fig. 2) for indentations greater than 15 μm in length. For shorter indentations the offset should be proportionately less. The shape of perfect indentation in knoop hardness testing is a parallelogram with the larger diagram seven times the other.

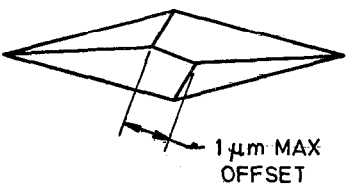

FIG. 2 KNOOP INDENTER OFFSET

4.3.2 The indenter faces shall be thoroughly smooth and free from cracks and other faults. The diamond shall be examined periodically. Irregularities around the indent may be an indication of poor indenter condition. If this is confirmed, the indenter shall be replaced.

5. TEST PIECE

5.1 Surface — The degree of surface preparation required for doing a test varies with the load applied and the hardness of the material to be tested. In general, surface finish shall be adequate to enable indent diagonals to be read accurately. For this purpose, it is often necessary to polish the test specimen mechanically, electrolytically or chemically singly or in any combination of these methods. In any case, all precautions should be taken to prevent the most superficial layer being altered in any way, for example, as a result of heating or work-hardening. If the surface is too irregular and the necessary preparation cannot be carried out, the hardness test should be done on a section of the layer. For this purpose, it is advisable to prepare a metallographic sample of the section. Then carry out the microhardness test on the section after preparing the sample as for a normal microscopic examination.

5.1.1 *Curvature of the Surface* — Surface curvature introduces an error in determining microhardness which increases as the radius diminishes. On convex surfaces greater hardnesses and on concave surfaces lesser hardness than actual ones are obtained.

5.1.2 *Surface Inclination* — If the surface is inclined with respect to a surface perpendicular to the axis of the penetrator, the extremities of the impression rest on different surfaces and there is a consequent difficulty if focussing the microscope and this leads to reading errors.

5.1.3 In addition to the factors already mentioned, measuring accuracy is influenced by the microscope's power of resolution.

6. TEST PROCEDURE

6.1 The test shall be carried out at the ambient temperature unless otherwise agreed to.

6.2 The specimen should be supported in such a way that the load is applied perpendicularly to the test surface and there is no movement of the specimen during the test.

6.3 It is essential to control the speed at which the load is applied to avoid penetrator impact against the test surface. Errors are greater with small loads and the test should be carried out with the speed reducing as the load is reduced. Some commercial instruments use constant load application speeds of the order of 15 to 70 μm/s. Such speeds may be excessive for small loads. To determine which speed is correct one, do 3 tests at a given speed and measure the indentation. Repeat the 3 tests with the same load at lower application speeds and calculate the mean length of the diagonals. If the mean obtaind at the lower speed is less than that obtained with a greater application speed, the greater speed is excessive. Repeat the test at gradually decreasing speeds until reduction of the load application speed no longer affects the dimensions of the indentation obtained. The speed below which there are no variations in the result is the one to use with the chosen load.

6.4 The load should normally be applied for between 10 and 15 seconds. Where it is necessary to do the test with different times, the actual time used should be reported in the result.

6.5 The load applied should be such that the depth of indentation is less than one tenth of the thickness of coating or case depth.

6.6 In cases where the surface is curved, knoop hardness values shall be corrected making the use of the appropriate factors, for example, determining the dimensions of an indentation obtained on a cylinder of equal radius and known hardness.

6.7 Distance from the indentation to the edge of specimen should be greater than the extent of any stress deformation as a result of the indentation process.

6.7.1 The distance between any two indentations should be greater than twice the extent of any stress deformation (*see* Fig. 3) that may occur as a

result of the indentation process so that there shall be no overlap of the deformation between the two indentations.

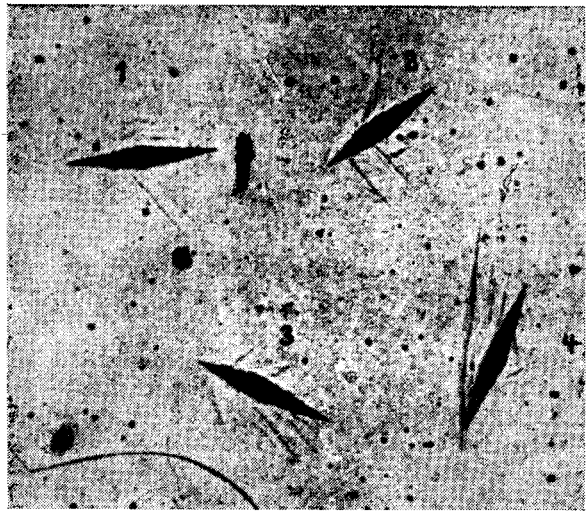

FIG. 3 PHOTOMICROGRAPH SHOWING KNOOP INDENTATIONS AND DEFORMATION IN THE ADJOINING AREAS

6.8 The microscope, which should provide maximum magnification of between 500 and 1 500 diameters, or any other type of measuring instrument employed and should be graduated in 0·5 μm or smaller divisions.

6.9 For each test at least three readings for each load and time shall be determined and the mean knoop hardness value calculated.

7. EXPRESSION OF RESULTS

7.1 In expressing the results the knoop hardness symbol *HK* should be preceded by the found value and followed by an index indicating the load and a possible second index relative to the duration of load application, when this is not between the normal limits of 10 and 15 seconds.

Example:

640 *HK* 30g/35 indicates knoop hardness of 640 measured under a load of 30 gf applied for 35 seconds.

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